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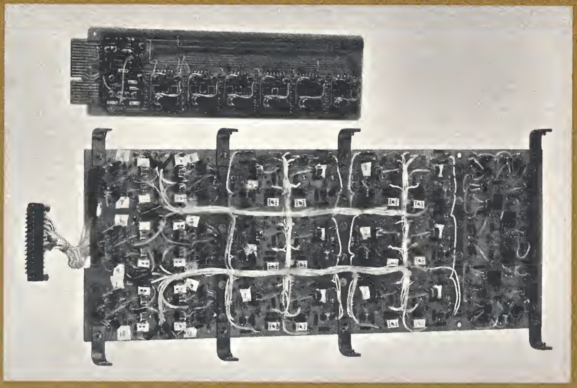
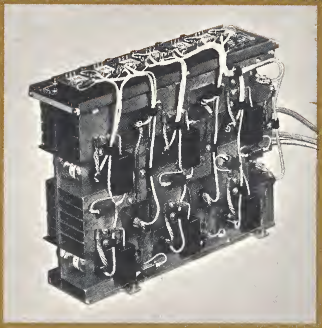
Integrated Cycloconverter

A cycloconverter is a step-down static frequency converter that produces a constant or a precisely controllable output frequency from a variable frequency AC power input. The device is not new in concept. In the past mercury arc rectifiers were used to implement cycloconverters, resulting in severe shortcomings: mercury arc cycloconverters were large and heavy, relatively inefficient, and sensitive to shock, vibration, and operating position. They generated a lot of heat, and required constant maintenance and tube replacements. They also required complex and cumbersome control circuitry. For these reasons cycloconverters were considered a lab curiosity, unsuitable to practical applications.

The Power Equipment Division of Lear Siegler, Inc., Cleveland, has overcome these limitations by building a lightweight, compact cycloconverter utilizing silicon controlled rectifiers (SCRs) in place of the mercury arc tubes, and using integrated circuits for control purposes. The resulting cycloconverter has an efficiency of up to 98.5% at full load, provides frequency control with accuracy as high as 0.00001%, and has improved reliability by an order of magnitude. The development of this unit has made practical the use of AC power in such applications as aircraft generating systems, variable speed squirrel cage motors, and many others (see below). The Lear Siegler cycloconverter consists of two groups of SCR's mounted in a full-wave configuration, on high efficiency aluminum heat sinks. A three-phase AC power supply provides the input frequency. Monolithic integrated circuits mounted on top of the unit provide firing and blanking control. The blanking control inhibits firing signals to the positive group of SCRs while the negative group is conducting, and vice versa. This eliminates the need for interphase chokes, and considerably improves the efficiency of the unit. The output frequency can be precisely varied from dc to one half of the input frequency. A total of 185 components, of which 30 are integrated circuits, are used for firing and blanking control, compared to 1324 discrete components previously required, a saving of 7 to 1. Furthermore, only three circuit types of the DTL family and one linear circuit type are used. Cost data developed to date indicates a reduction in fabrication costs of frequency converter board assemblies by a factor of 2.5 to 1. The unit has been subjected to severe reliability tests, and has operated without interruption for 4200 hours at 100kW from a plant power line with a 100 volt transient.



Comparison of firing and blanking control logic boards as implemented with IC's and with discrete components.



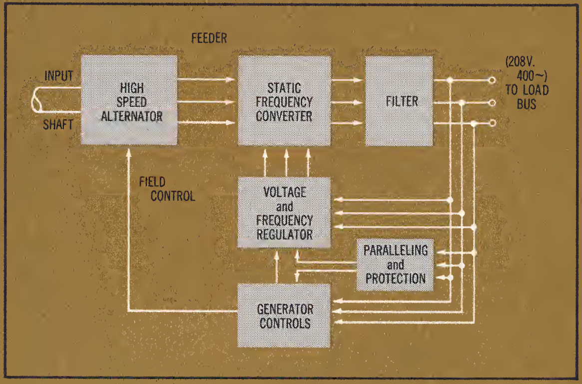
Cycloconverter module made by Power Equipment Division, Lear Siegler, Inc.

Cycloconverter Applications

VSCF GENERATING SYSTEM FOR AIRCRAFT: A variable speed constant frequency (VSCF) generating system for helicopter and fixed wing aircraft using the integrated cycloconverter has been built by Lear Siegler (see block diagram). Power is provided to the system from a high speed alternator driven by the aircraft engine. The alternator speed can vary over a 3:1 or 2:1 speed ratio without affecting the quality of power delivered to the load bus, so long as the alternator frequency remains above 800 Hz for a 400 Hz system. A full wave bridge configuration is used for the cycloconverter, to give the unit improved performance characteristics. This configuration is possible because of size and cost economies achieved through integrated circuit firing controls. The single phase frequency converter module is less than 8 pounds, and it supplies a 100 KVA load in a 50°C ambient, and a 50 KVA load in an 85°C ambient.

VARIABLE SPEED SQUIRREL CAGE DRIVE: The availability of a practical solid-state frequency converter has made possible the use of a polyphase squirrel cage motor as an adjustable speed drive. Such a system provides superior weight to horsepower ratios of less than one pound per horsepower. It has the added advantage, when applied to multi-wheel land vehicles, of automatic torque control. This is accomplished by means of a tachometer signal which is fed back into the firing control circuitry. The effect is to transfer any excess power from a wheel which is slipping to the wheel with the surest footing. A similar system can also be used to furnish power to locomotive drive systems such as rapid transit railways and diesel locomotives.

OTHER APPLICATIONS: The cycloconverter opens the door for utilization of AC power drives in a wide variety of applications. Wheeled vehicle drives, tracked vehicle drives, antenna drive systems, industrial process drives, and rapid transit railway drives are currently being built by the Power Equipment Division of Lear Siegler. Many other applications are under investigation and in various stages of completion.



Variable speed constant frequency generating system block diagram.

FAIRCHILD SEMICONDUCTOR

INDUSTRIAL APPLICATIONS FOR FAIRCHILD INTEGRATED CIRCUITS

6

of a series

The Switch to IC's:

The Handwriting on the Wall

Integrated circuits are gaining acceptance in industry at a rate much faster than previous technological breakthroughs. It took transistors, for example, about 10 years to get from the drawing boards to electric guitars. But integrated circuits, which only two years ago were in the highly exotic, state-of-the-art category, are already making a limited appearance in home television sets, and are rapidly gaining a position of dominance in the industrial market. There are some technical reasons for this accelerated pace of acceptance, but there are also compelling marketing reasons. In the competitive electronics industry, these reasons tend to dominate.

TECHNICAL REASONS: When transistors started to replace vacuum tubes they brought with them a whole new manufacturing technology: printed circuit boards, flow-soldering techniques, automated insertion tools, and the like. No such change in manufacturing procedure is necessary when you switch from transistors to integrated circuits. The technology exists, and can be readily adapted, especially since most integrated circuits are available in standard transistor packaging.

Some applications made the switch because of size and performance advantages. Modern computers operate in the nanosecond range, and a nanosecond is about the length of time it takes electric current to flow through a foot of wire. The size reduction possible with integrated circuits often eliminates enough wire to have a significant effect on the speed of the computer.

MARKETING REASONS: In industrial electronics, where the speed of light is rarely an important criterion, the reason for the rapid changeover to integrated circuits has been an improved cost/performance ratio. A manufacturer of test equipment, for example, recently discovered that he could add a function to his instrument by simply adding one additional integrated circuit. Previously the same function required a board which was offered as a $100.00 option. Now the instrument includes it in its base price, which is still below what the discrete component equivalent sold for. This case is typical. Obviously, more performance at less cost is a sales story every manufacturer is eager to make his own. And so the switch to IC's is on.

CUSTOMER DEMANDS: Most important, the word has reached many customers that integrated circuits are more reliable, perform better, and cost less than discrete component equipment and systems. Consumer appliance manufacturers who include even a single integrated circuit in their electronics are quick to advertise their more advanced, more reliable equipment to the public. And so both industrial and consumer manufacturers find that they must switch to integrated circuits to give their customers what they want.

THE MORAL: The question for a company making equipment containing electronics is therefore not whether to switch to integrated circuits, but when and how. The when is simply answered. If you're not already planning the changeover, start now, while you may still get a jump on competition, or at least keep up. The how is not so simple: you'll need some basic information. The enclosed postcard will bring you an abundance.